Drinking Water Vulnerability: Development and Validation of a Multidimensional Measure.

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RESEARCH PROBLEM

Water insecurity is a pressing global issue that impedes progress toward achieving the United Nations Sustainable Development Goal 6, which calls for universal and sustainable drinking water and sanitation access (Herrera, 2019). This challenge is exacerbated by the increasing demands on drinking water resources from population growth, industrialization, and the effects of climate change (Adams et al., 2020; Al-Kaisi et al., 2013). Despite widespread recognition of water insecurity's critical impact on health, livelihoods, and gender equality (Allouche et al., 2011; Brewis et al., 2019), existing measures to assess it, such as water insecurity scales (Young et al., 2019, 2021), often fail to encapsulate its complex, multifaceted nature. These scales, while valuable, typically do not address the full spectrum of factors that contribute to drinking water vulnerability, such as socioeconomic and environmental elements.

To address this challenge, our research attempts to develop, refine, and further validate a Drinking Water Vulnerability Scale (DWVS) based on its underlying constructs. Consistency in measurement is important to this field so comparisons can be made across studies and to develop a reliable understanding of water perceptions and access. The measure is based on previously used items and assessments in the literature. It aims to understand water vulnerability as a hierarchical concept composed of multiple factors, thereby capturing a more holistic picture of water insecurity. The measure assesses four theoretically key dimensions of drinking water insecurity: quantity, affordability, quality, and source sustainability. The quantity dimension considers the physical availability of drinking water resources, including the presence and adequacy of drinking water to meet daily needs. Affordability examines the economic aspects, assessing the accessibility and financial burden of obtaining drinking water services. The quality dimension evaluates safety concerns, specifically the risk of contamination and the health implications of drinking water consumed. Lastly, source sustainability investigates the long-term viability and resilience of drinking water resources, an aspect often overlooked in existing scales.

The DWVS is set to assess drinking water-related challenges by integrating these dimensions, thus providing a valuable metric for policymakers, stakeholders, and researchers. It has the potential to facilitate more targeted interventions, enabling the identification of specific vulnerabilities within communities and the allocation of resources where they are most needed. Furthermore, the scale can contribute to the monitoring and evaluation of water security interventions over time, offering insights into their effectiveness and the progress made towards SDG 6. By proposing the DWVS, this research aims to contribute to a more profound understanding of water insecurity, ultimately aiding global efforts to achieve a water-secure world for all. The scale's multidimensional approach recognizes that water insecurity is not merely a matter of insufficient drinking water supply but is deeply entwined with socioeconomic, environmental, and health-related factors. With its scope, the DWVS promises to be a significant step forward in measuring and mitigating water insecurity in diverse contexts worldwide.

BRIEF RESEARCH METHODOLOGY AND APPROACH

This study was designed to encompass 'hot zones' in the United States that have been at the forefront of drinking water challenges. Notable among these are Flint, Michigan; Newark, New Jersey; and various Alaska Native communities, all of which have featured prominently in the news due to their water-related crises (Butler et al., 2016; Pauli, 2020; Takahashi et al., 2020). These areas were included to ensure the DWVS could accurately reflect the water insecurity faced by communities in crisis and to test the scale's robustness in diverse and challenging environments.

Data collection was undertaken in November of 2023, over a month-long period, by a specialized team from Iowa State University's Center for Survey Statistics & Methodology. This effort involved engaging with 1,594 participants, 800 of them across the 'hot zone' regions, ensuring a statistically representative sample and sensitive to the acute issues faced by communities in these hot zones. The survey captured a wide array of socioeconomic demographics such as age, gender, income, educational levels, years of residency, and race—variables that are often interrelated with water security. The survey gathered data on various drinking water sources, including tap, filtered tap, well, stream, harvested rain, and bottled water. Understanding the range of sources used by households across these hot zones was crucial to assessing the multifaceted nature of water insecurity, from the physical availability of water to the reliability and safety of these sources. This study was reviewed by the Iowa State University Institutional Review Board (IRB) to ensure ethical research with human subjects.

KEY FINDINGS AND IMPLICATIONS

An initial exploratory factor analysis has revealed that the Drinking Water Vulnerability Scale (DWVS) effectively identifies four key aspects of water vulnerability using 30 items. These aspects are: 1) Water Quality and Quantity; 2) Trust in Water Utility; 3) Water-Related Health Concerns; and 4) Water Service Cost and Reliability. The DWVS may comprehensively assess several aspects of individuals' water issues. The factor structure was consistent with the theory on water insecurity in the USA.

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